RESEARCH ARTICLE OPEN ACCESS

Analysis of the Small Wind Turbine Blade with and Without Winglet

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ABSTRACT
This paper deals with the experimental verification the small wind turbine blade with and without winglet. Winglet is smaller portion to be added in the end of blade and measured its noise and performance. In the experiments the output power of generator is increased about 2.01% and noise level is reduced 25% in the winglet blade respectively compared with the without winglet blade. In addition, the experimental values the performances of the blades were compared with the CFD, Noise Analyzer are used.
***Keywords*–**CFD, Noise, Output power, Performance, Small Wind Turbine Blade, Winglet,

I. INTRODUCTION

This present work is carried out in outlining a wind turbine blade utilizing the Blade Element Theory for a length of 1.5 meters which is suitable for 2.0 KW little wind turbine. The harmony lengths are ascertained and the harmony circulations, stream edges, the differential power, push and torque are all at discrete interims of the blade are plotted. The turbine blade is then thought to be a decreased empty shaft. The characteristic recurrence is discovered by taking care of the Eigen esteem issue. The sharpened steel proficiency could be expanded by joining a winglet to the end of the turbine blade. The winglets are regularly utilized within the aviation vehicle outlines.

Lot of research on finding the optimum chord lengths has been made using a variety of evolutionary optimizing techniques. Some work that forms the background for this research is as follows [1] Arvind Singh Rathore and Siraj Ahmed optimizes the rotor design for a 750 MW of blade length 21.0 m airfoil selected is S809, the stress and deflection in the bade and the hub are checked and concludes that the stress and deflections are reduced [2] H. V. Mahawadiwar, et.al,used CFD software to optimize the blade angle (beta angle), co efficient of performance by analyzing the newly desined blade at various wind speed conditions [3]M. Jureczko, M. Pawlak, A. Mezyk used the BEM theory to design and used ANSYS for calculation of natural frequencies. They had found out the mode shape of the blades by using the Timoshenko twisted tapered beam element theory. The genetic algorithm was used to minimize blade vibration, maximize output, minimize blade cost and increase stability [4] NitinTnguria, et.al designed blade of 38.95m for V82-1.65 MW Horizontal axis wind turbine, they used Glauert's optimal rotor theory. The material for both blade and spar were made of composite materials. They used ANSYS for analyzing their work to compare the reslt with the previous experimental work resulting the deflection is reduced [5] Z.L. Mahri and Rouabah had calculated the dynamic stresses on a blade which was designed the blade element theory. The rotor diameter was 10 meters and the dynamic analysis was made using the beam theory and the modal analysis is made using the finite element modeling and also using the blade motion equation [6] Karam and Hani optimized using the variables as cross section area, radius of gyration and the chord length, the optimal design is for maximum natural frequency. The optimization is done using multi-dimensional search techniques. The results had shown the technique was efficient [7] Wang Xudong, et al used three different wind turbine sizes in order to optimize the cost based on maximizing the annual energy production for particular turbines at a general site. In their research using a refined BEM theory, an optimization model for wind turbines based on structural dynamics of blades and minimizes the cost of energy. Effective reduction of the optimization was documented [8] Rinaldo Gonzalez Galdamez, et al moeled wind turbine winglets using computational fluid dynamics (CFD) with turbulent models integrated in the simulation in order to improve the aerodynamic forces and aerodynamic analysis of the winglet at the tip of the rotor blade and concluded in improved performance of the blade [9] K.J. Johansen, and Sorensen N.N, modified the tip of the rotors to winglet to improve the aerodynamic performance of turbine rotors and to make them less sensitive to wind gusts [10]K.J. Johansen, and Sorensen N.N, modified the tip of the rotors to winglet to improve the aerodynamic performance of turbine rotors and to make them less sensitive to wind gusts.

II. ANALYSIS

The cross section was finished by utilizing the Hyperworks 11.0, then foreign made into FLUENT and in the wake of checking for conceivable slips and general nature of the lattice, the recreation setup could be begun. The requisition of a solitary moving reference edge gives the focal point of rendering the transient nature of a turning issue an unfaltering issue, nonetheless it was watched that at high wind speed speeds, when residuals arrived at a steady esteem, a little semi sinusoidal pattern might create; this proposes, that the issue still shows shaky characteristics, along these lines, a proper transient information ought to be given. The mesh file of the wind turbine blade assembly is shown in the figure 2.1.

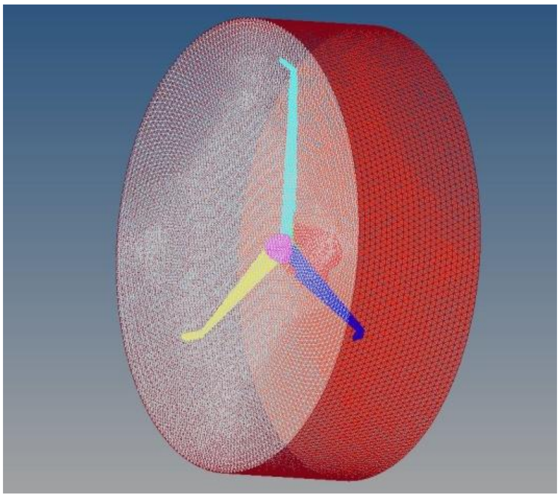

Figure 2.1 Meshed Wind Turbine Assembly with boundary

1.1 BOUNDARY CONDITIONS

The defining of the Limit Conditions (BCs) is an extremely vital step; along these lines BCs must be legitimately connected. Below is a list of the used BCs shown in Table I,

Table I: Assigned boundary conditions

Parameter	Values
Inlet velocity	2.0 – 4.0 m/s
Outlet	Outflow
Rotating Part Speed	800 rpm
Operating Pressure	0 Pa

1.2 VELOCITY-INLET

At the point when managing incompressible streams, the speed must be specified at the channel of the cross section. It could be specified as both steady and variable, either typical to the surface or acting with a specified plot (as might be in a yaw-study case). For this situation it was specified as steady and perpendicular to the limit. Turbulence conditions likewise must be characterized here and the default turbulence parameters of the NASA Ames Wind Tunnel were utilized, that is, delta turbulence power of 0.5 % and consistency proportion set to 10. The inlet and outlet of the flow of the fluid is shown in the figure 2.2.

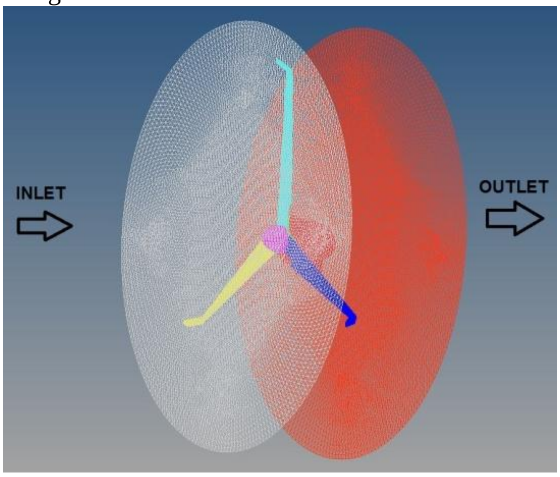

Figure 2.2 Inlet and Outlet of the boundary

1.3 PRESSURE-OUTLET

This limit condition was connected at the outlet of the space and sets the weight at the limit at particular static weight esteem. In this study, the evident decision was to put the quality equivalent to zero so the weight at the outlet might be equivalent to the barometrical working weight (standard weight adrift level was utilized, i.e. 101,325 Pa).

III. SOLUTION METHOD

The weight based discretization plan is constantly connected and since registering fittings allowed, the coupled calculation, which tackles in one stage the arrangement of force and weight based coherence mathematical statement, could likewise be utilized, therefore lessening computational times. With FVM, scalar amounts are characterized at the focal point of cells although convection terms are put away at the substance of the cells. These last terms must be found by method for addition from the inside of the control volume, in particular upwind plan. In the analysis program, there are distinctive systems that might be utilized, for example, first- or second-order upwind plan.

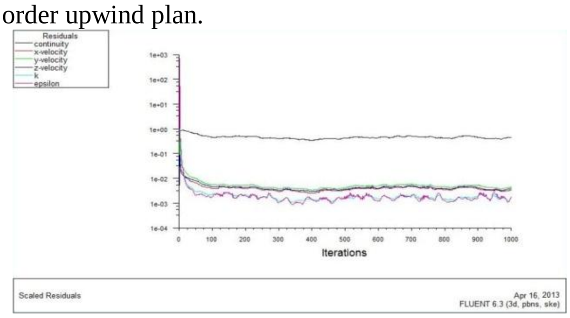

Figure 3.1 Iterations for Wind speed 2.0 m/s

Figure 3.2 Static Pressure for Wind speed 2.0 m/s

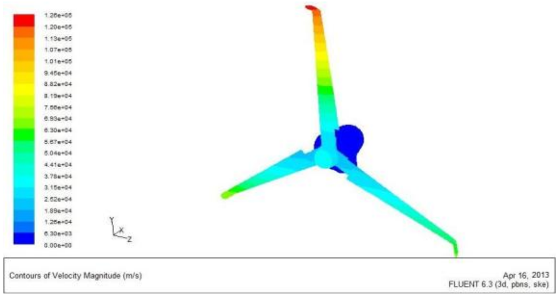

Figure 3.3 Velocity Magnitude for Wind speed 2.0 m/s

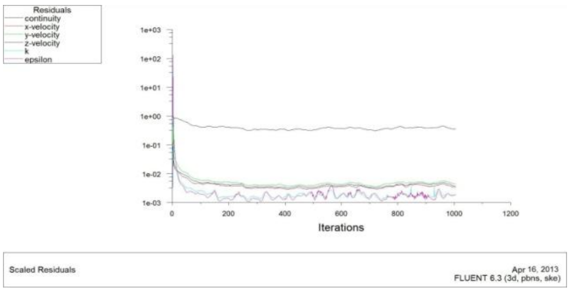

Figure 3.4 Iterations for Wind speed 3.0 m/s

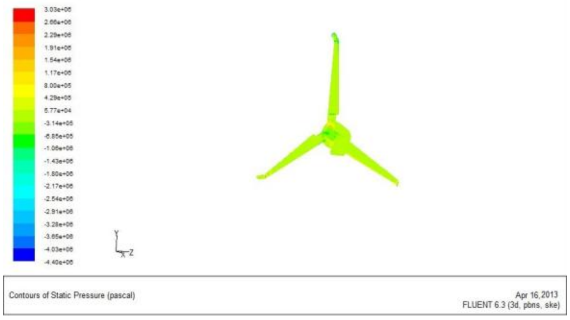

Figure 3.5 Static Pressure for Wind speed 3.0 m/s

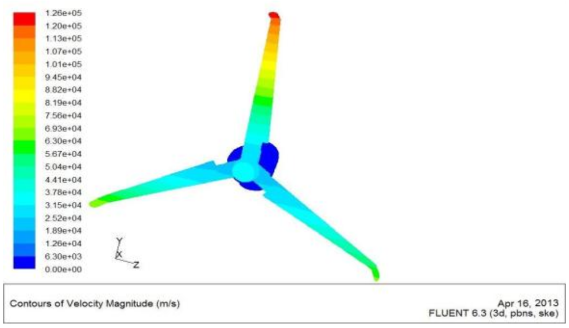

Figure 3.6 Velocity Magnitude for Wind speed 3.0 m/s

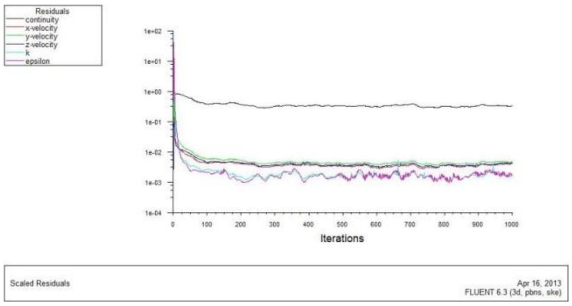

Figure 3.7 Iterations for Wind speed 4.0 m/s

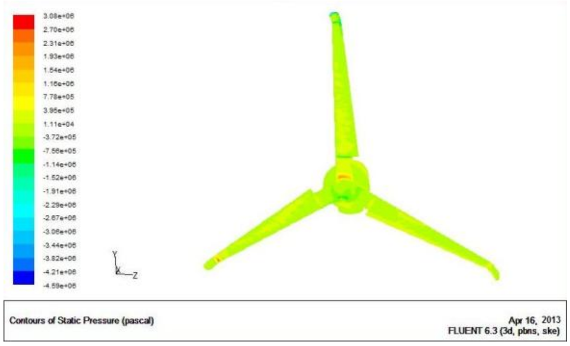

Figure 3.8 Static Pressure for Wind speed 4.0 m/s

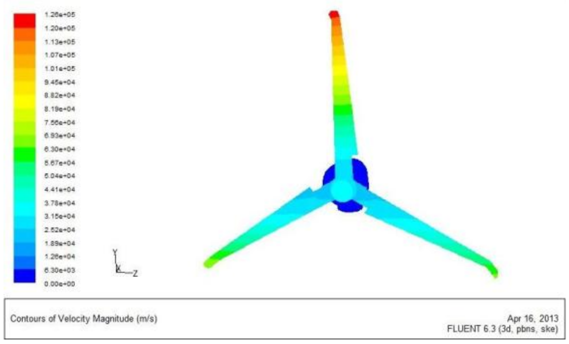

Figure 3.9 Velocity Magnitude for Wind speed 4.0 m/s

Over the figures indicates the cycle qualities are concurrent at 1000 iterations in plain blade utilizing above same conditions the meeting at 850 cycles after that values does not change. So similarly winglet added turbine blade is better execution to the plain blade.

IV. TESTING CONDITIONS

The testing condition was up to the standard atmospheric state in the field. The various parameters noted during the test are listed below in Table II.

Table II. Testing Conditions

Description	Values
Temperature	26 – 29°C
Wind speed	1.8 – 4.6 m/s
Pressure	101.325 N/m^2
Tower Height	7.12 m
Generator Capacity	2 KW
Output mode	3 Phase
Plane Blade weight	2.899 kg
Winglet blade weight	3.112 kg
Test dates	
For plane blade	14.03.2013 – 16.03.2013
For winglet blade	18.03.2013 – 20.03.2013

The conditions were weighed in the field for a specific interim of time period. The wind pace and temperature was checked with the anemometer and thermometer, then the yield qualities are taken from the testing of the wind turbine setup. The blade assembly is lifted to that stature with the assistance of cranes and amassed with the assistance of man and machine power.

V. Result And Discussion

5.1 Voltage VS. Wind Speed

From the underneath two diagrams we thought about the yield voltage levels of both the blades in the working conditions. In the plane blade the greatest yield voltage of 99 volts is achieved in wind speed 4.0 m/s in R and B stage. In the winglet blade the most extreme yield voltage of 124 volts is achieved in wind speed 4.0 m/s in R stage.

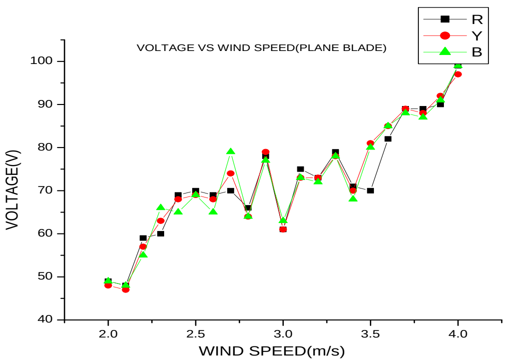

Figure 4.1 Wind speed vs. Voltage (3 phase) – Plane blade

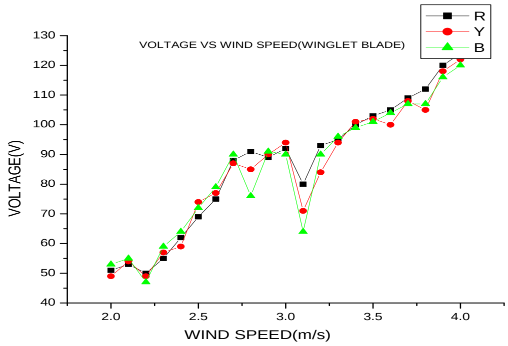

Figure 4.2 Wind speed vs. Voltage (3 phase) – Winglet blade

5.2 CurrentVS. Wind Speed

From the beneath two diagrams we looked at the yield current levels of both the blades in the working conditions. In the plane blade the greatest yield present of 2.18 amps is achieved in wind speed 4.0 m/s in R and B stage. In the winglet blade the most extreme yield voltage of 2.73 amps is accomplished in wind speed 4.0 m/s in R stage.

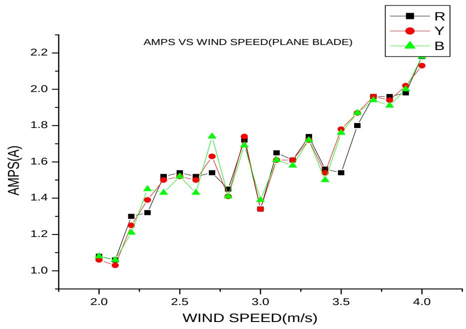

Figure 4.3 Wind speed vs. Ampere (3 phase) – Plane blade

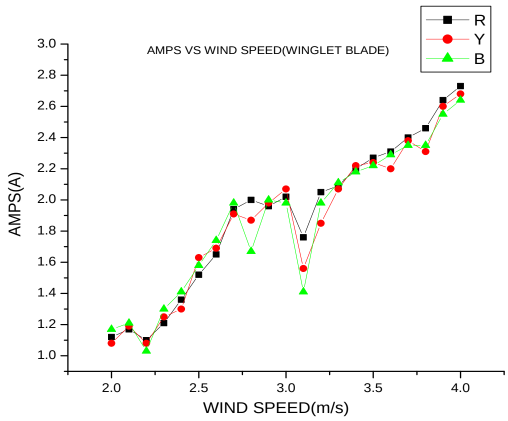

Figure 4.4 Wind speed vs. Ampere (3 phase) – Winglet blade

VI. NOISE LEVEL

As far as possible apply to the aggregate clamor from all wind turbines and are situated for both frail winds, when commotion is discovered to be most irritating, and stronger winds. At the point when the clamor meets as far as possible it don't imply that the commotion is indiscernible.

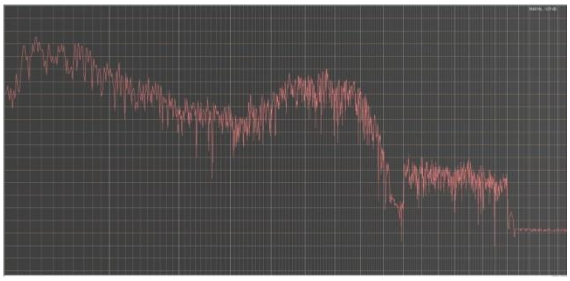

Figure 5.1 Noise level graphs for Plane Blade

The clamor level processed in the plane blade is delineated in the above figures. The clamor level was noted at a separation of 3 meters from the tower and that recorded and examined utilizing the Audiopad programming. They came about commotion level for the plane blade is something like 109 db.

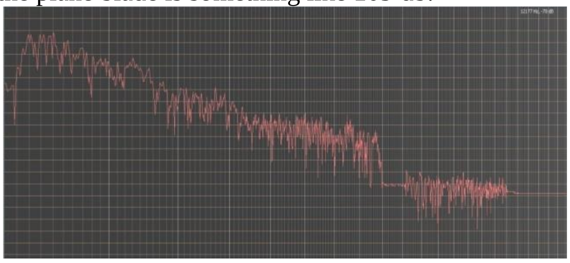

Figure 5.2 Noise level graphs for Winglet Blade

The clamor level transformed in the winglet blade is outlined in the above figures. The clamor level was noted at a separation of 3 meters from the tower and that recorded and investigated utilizing the Audiopad programming. They came about clamor level for the plane blade is something like 78 db.

VII. CONCLUSION

The winglet design process completed using ProE software after that the analyses work has been carried out using the required software in a standard method. From that comes about we are assembling the continuous blades and discovering the accompanying outcomes.

- The design and manufacturing process was taking more time.
- The implemented blade noise level is reduced about 25% compared to plain blade.
- The wind speed limits for operating the blade has been improved for the winglet attached blade.

ACKNOWLEDGEMENTS

The project work carried on the KST Windengineering India, Kethanur, Tirupur. And specially thanks Mr. S. K. Shreenivas, CEO of the KST Windengineering India. And also thanks to his team for supporting us to complete the project successfully.

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